THE ROLE OF "CAPABILITIES" IN DEVELOPMENT: HOW SOME COUNTRIES MANAGE TO CATCH UP

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1. Introduction

Is there an inbuilt tendency for productivity and income across the globe to converge? If we look at capitalist development in a long run perspective the answer is clear. The long run trend since the so-called industrial revolution has been towards divergence, not convergence in productivity and income. For instance, according to economic historian David Landes, 250 years ago the difference in income or productivity per head between the richest and poorest country in the world was approximately 5:1, while more recently this difference has increased to 400:1 (Landes 1998). However, in spite of this long run trend towards divergence, there are many examples of (initially) backward countries that – at different times – have managed to narrow the gap in productivity between themselves and the frontier countries, in other words, to "catch up". The current frontier country – the United States – was itself once on a catch-up path vis-à-vis the then economically and technologically leading country of the time, the United Kingdom. Japan in the decades before and after the Second World War is another well-known example and the so-called "Asian tigers" from the 1960s onwards. China and India are examples of countries that may have joined this path more recently (although they still have a long way to go).

The question that suggests itself is how this diversity in patterns of development can be explained. Why do some countries succeed in catching up, while others fall behind? Is it related to the development of "capabilities" of a type that other countries fail to create? In fact, this is one of the oldest and most controversial issues in economics. It can be traced back at least a few hundred years, when politicians and industrialists in countries such as the United States and Germany started to debate what types of capabilities and policies that were needed in order to catch up with the then world leader, the United Kingdom (see Chang 2002).

In section 2 we start the search for what these critical factors for catch-up may be. We do this by reviewing some of the main arguments that have been presented in the literature and discussing what empirical measures these give (or may give) rise to. Traditionally, much theorizing in this area focused on the role of capital accumulation for growth and development. Gradually this has given way to a more "institutionalist" view, focusing on how to get the institutional conditions for well-working markets, including the capital market, right. More recently we have seen development of a more "knowledge based" approach, according to which catching up (or lack of such) depends not so much on capital accumulation as the abilities of a country to create and exploit knowledge (and respond to challenges arising in connection with this). This naturally leads to a focus on what influences the capacity of a country for creating and exploiting knowledge, including relevant policy aspects, and concepts such as "social capability" and "absorptive capacity" have emerged as important focusing devices within this approach.

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Having considered the various arguments and the empirical measures they give rise to we start in section 3 on the synthesis work. In recent years the quality and availability of data on different aspects of development have improved a lot, and this might give researchers a new opportunity for investigating the reasons behind the large differences in economic performance in more depth. Rather than picking individual indicators we follow Adelman and Morris (1965, 1967) and Temple and Johnson (1998) in mapping the most central elements with the help of factor analysis, taking into account a variety of different indicators and sources. Factor analysis is a useful tool in the present context because it allows us to reduce the complexity entailed by a large number of different (but often mutually correlated) indicators into a smaller number of synthetic dimensions. The analysis clearly illustrates the multidimensional character of "capabilities", resulting in four different dimensions, which we label "innovation system", "governance", "political system" and "openness", respectively. We examine the relationships with economic development and analyse to what extent these capabilities may help us understand why some countries excel economically, while other countries continue to be poor.

2. What are the most critical factors for development? Taking stock of the literature.

Intuitively, most people easily accept the idea that knowledge and economic development is intimately related, and hence that access to knowledge should be regarded as a vital factor. However, this is not the way different levels of development used to be explained by economists. From the birth of the so-called "classical political economy" – a term invented by Karl Marx - two centuries ago, what economists have focused on when trying to explain differences in income or productivity is accumulated capital per worker. Similarly, differences in economic growth have been seen as reflecting different rates of capital accumulation. This perspective arguably reflects the important role played by "mechanization" as a mean for productivity advance during the so-called (first) industrial revolution, the period during which the frame of reference for much economic reasoning was formed. Closer to our own age Robert Solow adopted this perspective in his so-called "neoclassical growth theory" (Solow 1956). The theory predicted that, under otherwise similar circumstances, investments in poor countries (e.g. those with little capital) would be more profitable than in the richer ones, so that the former would be characterized by higher investment and faster economic growth than the latter. As a consequence of this logic, a narrowing of the development gap (so-called "convergence") should be expected.

It soon became clear, however, that this could not be the whole story. When students of economic growth started to apply this perspective to long run growth processes in the United States and elsewhere, they found that capital accumulation, or factor accumulation more generally, could only explain a relatively small share of actual growth (Abramovitz 1956). This finding has since been repeated many times for different data sets.[3] Moreover, as pointed out above, the prediction that global capitalist dynamics would be accompanied by a convergence in income and productivity between initially poor and rich countries was not borne out of the facts either.

From capital accumulation to institutions and geography

It should be emphasized, however, that Solow's theory was based on standard neoclassical assumptions on how markets and agents perform, which might not fit very well in developing countries. Hence, one possible explanation for the failure of many countries to catch up could

3 See Fagerberg (2004) for an overview and discussion and Easterly and Levine (2001) for recent evidence on the subject.

be that markets did not work properly, agents did not receive the right incentives, the government interfered too much in the economy etc., in short; that "the rules of the game" were not adhered to. Following the terminology used by Douglas North (1981) such rules are customary called institutions. But in common parlance as well as in some scholarly work, the concept institution is also used in a broader sense, to include not only rules and norms but also organizations and other types of collaborative activities that may influence individual behaviour.

Taking issue with the role of institutions for growth and development Glaeser et al. (2004) argue that institutions in the narrow sense of the term (rules, norms) should be expected to be relatively stable over time. This follows from the view that such rules and norms are deeply embedded into society and, hence, change slowly. However, the authors point out that many commonly used indicators of "institutions" are far from stable. Hence, they conclude that such indicators in many cases do not reflect "institutions" in the above sense, but rather political choices and policies pursued by governments, which may be assumed to be subject to more frequent changes than historically given rules and norms. They also show that if the analysis is restricted to indicators of institutions in the narrow sense (reflecting constitution or judicial system) and their relationship with levels and growth of GDP, the correlations are rather weak, in contrast to what can be shown to hold for the more broadly defined "institutional variables" (which Glaeser et al. see as reflecting political choices). Thus, institutions in the more narrow sense are not good predictors of successful catch-up. What seem to be of greater importance are the policies actually pursued.

In recent years, a sizeable empirical literature has emerged trying to expand on the type of analysis just presented in various directions, for instance by pushing the search for explanatory factors far back in time (Acemoglu et al. 2001, 2002), or by taking into account other types of exogenous variables that might have an impact on development (and policies), such as climate, exposure to diseases, geography (access to sea for instance), ethnic diversity etc. (Sachs et al. 2004, Masters and MacMillan 2001, Bloom et al. 2003, Alesina et al. 2003). Arguably, it is difficult to deny that factors of a historical or geographical nature may have an impact on long-run growth. Hence, it appears pertinent to control for this when testing for the impact of other factors, and we will follow this practice here. It might be noted, however, that in many cases there is conflicting evidence and interpretation about the impact of history, geography and nature on growth (Glaeser et al. 2004). One reason for this may be that variables reflecting different causes sometimes are so strongly correlated that little can be said with certainty (apart from, perhaps, that there is a joint impact). Alesina et al. (2003, p. 183), for instance, conclude on this basis that "In the end one has to use theory and priors to interpret our correlations". Another possibility, pointed out already by Moses Abramovitz (1994a), could be that the problems that such conditions give rise to, may also spur the creation of new knowledge and new social arrangements, which eventually may totally eliminate the problems (and even making society better off over a long-run). This leads us to the role of knowledge in growth and development.

Knowledge and development

"Knowledge", or "knowing things", may take many forms. It may be theoretical, based on an elaborate understanding of the phenomena under scrutiny. But it may also be practical, based on, say, cause-effect relationships that have been shown to hold in practice, although a total understanding of the underlying causes may be lacking. It may be created through search or learning but it may also be acquired through education or training or simply by observing what others do and trying to imitate it. The creation (or acquisition) of knowledge does not

require an economic motive (or effect), although this is quite common. The subset of knowledge that deals with how to produce and distribute goods and services, which is what interest economists most, is usually labelled "technology". An open question is if the concept technology only refers to knowledge about physical processes ("hardware"), or if it also includes knowledge about, say, how to organize/manage these ("software"). For the study of growth and development the latter, broad interpretation of the term is probably the most meaningful. Arguably, mastery of physical processes is of dubious value if you don't know how to embed these in a well-organized production and distribution system.

Traditionally, economic theorists have faced great problems in incorporating knowledge (technology) into their analysis of development. This had to do with a particular view on knowledge that had come to dominate economics; knowledge as a body of information, freely available to all interested, that can be used over and over again (without being depleted). Arguably, if this is what knowledge is about, it should be expected to benefit everybody all over the globe to the same extent, and cannot be invoked to explain differences in growth and development. It is understandable, therefore, that the first systematic attempts to conceptualise the relationship between knowledge and development did not come from the economics mainstream but from economic historians. The economic historian Alexander Gerschenkron set the stage for much of the subsequent literature (Gerschenkron 1962).[4] Rather than something that exists in the public domain and can be exploited by anybody everywhere free of charge, technological knowledge, whether created through learning or organized R&D, is in this tradition seen as deeply rooted in the specific capabilities of private firms and their networks/environments, and hence not easily transferable. Compared with the traditional neoclassical growth theory discussed earlier writers working in this tradition painted a much bleaker picture of the prospects for catch-up.[5] According to this latter view catch-up is not something that can normally be expected to occur only by market forces left alone, but requires a lot of effort and institution-building on the part of the backward country (Abramovitz 1986, 1994 a,b).

During the 1980s and 1990s economists' interest in the possible role of knowledge (technology) for growth and development increased a lot. On the theoretical front an important development was the emergence of the so-called "new growth theory" (Romer 1986, 1990, Aghion and Howitt 1992) according to which differences in economic growth and development across countries should be understood as the outcome of differences in endogenous knowledge accumulation within (largely national) boarders. Although some newly created technological knowledge may spill over from one setting (firm or country) to another one (and hence benefit the latter at least as much as the former), there are according to this approach sufficient impediments to this process (being legal, such as intellectual property rights, or more informal in nature) to secure that in most cases the lion's share of the benefits will accrue to the setting in which the knowledge is created. This leads to similar conclusions with respect to the prospects for catch-up and convergence as the more informal, historically oriented tradition discussed above. Together, these two strands of research, which both focus on the role of knowledge in development though through different lenses, have inspired a lot of new work aiming at identifying the various factors or capabilities that affect the extent to which developing countries succeed in exploiting the global pool of knowledge to their own benefit.

4 However, Thorstein Veblen (1915) is usually credited with initiating the approach. See Fagerberg and Godinho (2004) for details.

5 This research tradition is sometimes called the "technology gap approach" to growth and development (Fagerberg 1987). For an overview and comparison with other approaches see Fagerberg (1994).

Capabilities

The starting point for much of the work on capabilities and development was Gerschenkron's historical analyses of European catch-up with the then technologically and economically leading nation, the United Kingdom. Gerschenkron (1962) pointed out that although the technological gap between a frontier country and a laggard represents "a great promise" for the latter (a potential for high growth through imitating frontier technologies), there are also various problems that may prevent backward countries from reaping the potential benefits to the full extent. His favourite example was the German attempt to catch up with Britain more than a century ago. When Britain industrialized, technology was relatively labour intensive and small scale. But in the course of time technology became much more capital and scale intensive, so when Germany entered the scene, the conditions for entry had changed considerably. Because this, Gerschenkron argued, Germany had to develop new institutional instruments for overcoming these obstacles, above all in the financial sector, "instruments for which there was little or no counterpart in an established industrial country" (ibid). He held these experiences to be valid also for other technologically lagging countries. In short, to use a more recent terminology, Gerschenkron argued that catch-up by poorer countries should be expected to be "conditional" on certain types of capability-building.

Moses Abramovitz, arguing along similar lines as Gerschenkron, also placed emphasis on the potential for catch-up by late-comers which he defined as follows: "This is a potential that reflects these countries' greater opportunity to advance by borrowing and adapting the best practice technology and organization of more productive economies" (Abramovitz 1994b, p. 87). He suggested that differences in countries' abilities to exploit this potential might to some extent be explained in differences in so-called "social capability".[6] These are some of the aspects of social capability that Abramovitz emphasized as particularly relevant:[7]

- technical competence (level of education),
- experience in the organization and management of large scale enterprises,
- financial institutions and markets capable of mobilizing capital on a large scale,
- honesty and trust,
- the stability of government and its effectiveness in defining (enforcing) rules and supporting economic growth.

The concept social capability soon became very popular in applied work, so popular that it may in fact be difficult to find a published paper in this area that does not make a reference to it. However, the concept is as Abramowitz himself noted[8] notoriously difficult to operationalize and this has left a wide scope for different interpretations. In fact, as we shall see, in many practical applications it assumed to be identical to some measure of educational attainment, which, although arguably an important aspect of social capability, clearly is a more narrow perspective than what Abramovitz had in mind.

Another popular concept in the applied literature on growth and development that touches on some of the same issues is "absorptive capacity". Wesley Cohen and Daniel Levinthal who suggested the term defined it as "the ability of a firm to recognize the value of new, external

6 The term "social capability" comes from Ohkawa and Rosovsky (1973).

7 This list is based on Abramovitz (1986, p. 387-390) and, in particular, two papers he published during 1994, see Abramovitz (1994a p. 34-35, 1994b, p. 88).

8 The concept is, as Abramovitz himself admitted, quite "vaguely" and "poorly" defined (Abramovitz 1994a, p. 24 and 36).

information, assimilate it and apply it to commercial ends" (Cohen and Levinthal 1990, p. 128). They saw it as largely dependent on the firm's prior related knowledge, which in turn was assumed to reflect its cumulative R&D. However, they also noted that the path dependent nature of cumulative learning might make it difficult for a firm to acquire new knowledge created outside its own specialized field, and that it therefore was important for firms to retain a certain degree of diversity in its knowledge base through, among other things, nurturing linkages with holders of knowledge outside its own organization. Although their focus was on firms, many of the same considerations seem to apply at more aggregate levels, such as regions or countries, and the concept has won quite general acceptance.

It should be noted, however, that the concept absorptive capacity refers not only to "absorption" in the received meaning of the term but also to the ability to exploit and create knowledge more generally. Cohen and Levinthal, being well aware of this, defended their position by arguing - with reference to relevant psychological literature - that the ability to assimilate existing and the ability to create new knowledge are so similar so there is no point in distinguishing between them (ibid, p. 130). Other researchers have placed more emphasis on making such a distinction, though. Zahra and George (2002), in a review of the literature on the subject, argue that the skills required for creating and managing knowledge differ from those related to its exploitation and that the two therefore deserve to be treated and measured separately. They term the latter "transformative capacity". Kim (1997) equates absorptive capacity with "technological capability" and identifies three different aspects of it; "innovation capability", "investment capability" and "production capability". In a similar vein Fagerberg (1988) and Fagerberg et al. (2004) distinguish between a country's ability to compete on technology (what they term "technology competitiveness") and its ability to exploit technology commercially independently of where it was first created (so-called "capacity competitiveness").

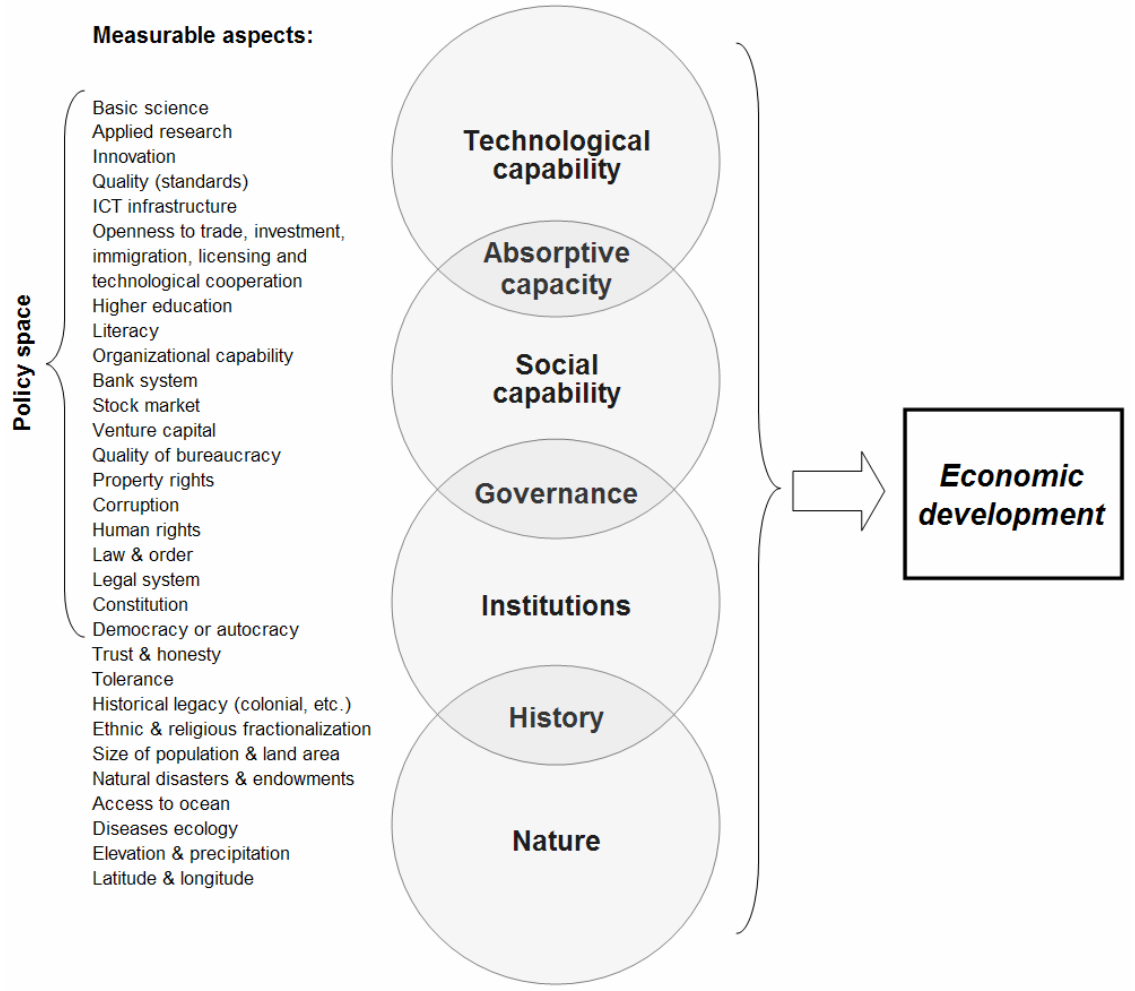
Thus there is by now a relatively large literature on the role of capabilities in development, conceptual and applied. However, as should be evident from the discussion, scholars in this area have suggested alternative concepts that are (at least partly) overlapping and often difficult to operationalize. The main purpose of this paper is to contribute to an improved (and more transparent) relationship between conceptual and applied work in this area. We start by examining the relationship between concepts and indicators, noting that the availability of indicators has improved a lot in recent years, and that this may prove to be beneficial not only for applied but also for conceptual work.

3. In search of a synthetic framework

Based on the preceding discussion, Figure 1 presents an overview of the factors that we expect to be of particular relevance for catch-up, along with possible indicators of these factors. Starting from the bottom we first have factors related to differences in geography and nature. Such factors are important for development, especially at an early stage, and are therefore important to take into account, although there is perhaps not so much one can do about it.[9] This also holds, to a large extent, for social characteristics that are the result of historical processes in the distant past, such as the roles of language(s), religion(s), ethnic groupings etc. Arguably, a part of what is commonly termed "institutions" (e.g. rules and norms) may also fall under this category. For instance, the differences across regions in attitudes towards social collaboration studied by Putnam (1993) and labelled "social capital" were shown to have their roots way back in history and to be remarkably persistent. As a consequence we do not include these in what we call the "policy space", shorthand for factors that within a reasonable time frame can be shaped through policy interventions. However, at any time there is a lot of scope for improvements in how society is governed (through appropriate political action). Hence, the quality of governance clearly belongs to the policy space. To this we also reckon the other aspects that Abramovitz included in his social capability concept (such as organizational competence, adequate financial infrastructure, education etc.) and factors associated with absorptive capacity and technological capability (such as, for instance, R&D infrastructure).

9 However, with increasing knowledge, the social and economic effects of such given conditions may change (learning to cope with diseases, for instance).

Figure 1
Capabilities and development - an integrated framework



The concepts "technological capability" and "absorptive capacity" both refer to the ability to develop and exploit knowledge commercially, what in recent literature is often seen as reflecting the "innovation system" of a country (Lundvall 1992, Nelson 1993). We have several data sources that capture different aspects of this dimension. As for "innovation capability" (to use the term suggested by Kim 1997) research and development (R&D) expenditures measure some (but not all) resources that are used for developing new products or processes while patents count (patentable) inventions.[10] The quality of a country's science base, on which innovation and invention activities to some extent depend, are reflected in articles published in scientific and technical journals.[11] In addition, a well-developed ICT infrastructure is widely acknowledged as a critical factor for the ability to develop and exploit new technology (knowledge). We include three indicators of ICT diffusion in the economy: personal computers, Internet users and fixed/mobile phone subscribers. However, ICT is

10 We use only patents granted by the United States Patent and Trademark Office (USPTO) to assure consistency in terms of criteria for novelty, originality, etc.

11 We consider both patent and article counts as very reliable sources of quantitative data. Note, however, that the propensity to patent or publish varies considerably across scientific fields and sectors/industries and that many innovations are not registered by these means. Moreover, there can be an upward language/regional bias for English-speaking nations and/or countries with a close links to the United States. No attempt was made to correct for these possible biases.

equally (or even more) important for another dimension of technological capability emphasized by Kim, namely "production capability". As an additional indicator of "production capability" we include the spread of quality standards in production, for which the ISO 9000 certification seems to be most relevant and broadly available indicator.

As pointed out in the literature on "absorptive capacity", openness (or interaction) across country borders may serve as an important channel of technology transfer (or spillovers) from abroad. This issue is also very much emphasized in work inspired by the so-called "new growth theories" (see, for instance, Grossman and Helpman 1991 and Coe and Helpman 1995). Four channels of technology transfer across country borders have been examined in the literature: migration, licensing, trade and foreign direct investment (FDI) (for an overview see Cincera and Van Pottelsberghe 2001). However, due to lack of data we only take into account the two latter, e.g.; diffusion of technology embodied in (merchandise) imports and (stock) of inward FDI. To avoid a bias against large economies (that for natural reasons trade/interact relatively more internally) both indicators were measured orthogonal to country size.[12]

An important aspect of "social capability", according to Abramovitz, is the ability to organize/manage large scale enterprises ("organizational capabilities"). This is, as acknowledged by Abramovitz himself, a hard thing to measure, particularly for a large sample of countries on different levels of development. Unfortunately, although we have scrutinized the available data sources for relevant information (se below), we have not been able to improve upon the existing literature in this respect. What most of the applied literature on the subject has done, following the influential study by Baumol et al. (1989), is to equate "social capability" with education, another aspect emphasized by Abramovitz. We include three indicators; the teacher-pupil ratio in primary education and the rates of enrolment[13] in secondary and tertiary education. Abramovitz also pointed to the crucial role of country's financial system for mobilizing resources for catching-up. We capture this aspect by the amount of credit (to the private sector) and by capitalization of companies listed in domestic capital markets. [14]

The importance of governance, policy and institutions, furnishing economic agents with incentives for creation and diffusion of knowledge, is also generally acknowledged in the literature. This holds not only for Abramovitz, who as mentioned previously included several such aspects into his definition of "social capability", but also for writers from other strands such as, for instance, "new growth theory". Although such factors often defy "hard" measurement,[15] especially in a cross-country comparison, there exist some survey-based

12 The variables were regressed against (the log of) country size (km^2) and the residuals from these regressions were then used in our analysis.

13 Note that we do not use indicators of enrolment in primary education, since this measure may have little impact on the labour force within the time span considered here, and has an upper boundary ("saturation" levels) that imply that many if not most countries will have values close to 100%. Indicators with this property are not well suited in factor analysis, because they tend to cluster into a single dimension due to this property alone, regardless of the content.

14 Note that Kim (1997) included finance (what he called "investment capability") in his definition of "technological capability", illustrating once more the partly overlapping nature of some of the most widely used concepts in this area.

15 Among the aspects included in Figure 1 (and emphasized by Abramovitz), and for which survey-based indicators do exist but with too low coverage to allow inclusion here, are "tolerance" and "honesty and trust" . In the more recent literature such aspects are often seen as related to "social capital", e.g. the ability of a population to engage in socially beneficial, cooperative activities, (see Woolcock and Narayan 2000 for an overview).

measures that may be considered here.[16] We include the following aspects (taken from such surveys):

- law and order,
- impartial courts,
- protection of property rights,
- how difficult it is to start/operate a business,
- size of informal market (extent of corruption),
- democratic versus autocratic government,
- checks and balances in the political system,
- degree of competition for posts in the executive and legislature and
- the extent of political rights and civil liberties.

These indicators clearly refer to institutions both in the broad sense ("quality of governance") and in the narrow sense ("rules of the game"). [17] One of the challenges in the following will be to find ways to distinguish between these two aspects.

Although measurability is a key issue for the present exercise, data availability proved to be a serious concern as well. Typically, most developed market economies figure prominently among those with good coverage, while many developing countries and former socialist economies lack data on many potentially useful indicators (and years). Based on an initial screening of data for 175 countries and more than 100 potential indicators we chose to include 115 countries and 25 indicators into the analysis (see Appendix 1 for details). Still there were a few missing data points for many countries/indicators. Excluding all countries with one or more missing observations would inevitably lead us in the direction of only considering a small group of highly developed countries. The same goes for indicators, not taking into account all indicators for which some country lacked data would lead to ignore many of the potentially most interesting explanatory factors. In such cases we therefore chose to estimate the missing observations with the help of information on other, similar, indicators/countries (rather than reducing the sample).[18] To ensure comparability over time and across countries, all indicators were measured in real units (quantity), deflated (if applicable) with population or GDP and on an increasing scale from low score (weak) to high score (strong).[19] To limit the influence of shocks occurring in specific years, we express all indicators as three-year averages for the initial period over 1992-1994 and for the final period over 2002-2004.

16 The sources of the data include expert panels and surveys provided by the Heritage Foundation, Freedom House, Polity IV Project, Transparency International, Amnesty International, World Economic Forum, PRS Group, Economic Intelligence Unit, various U.S. based State Agencies and others (see the Appendix A1 for details).

17 Note that because of limited or no time-series, we cannot use the indicators developed by Djankov, et al. (2002), Botero, et al. (2004) and the World Bank's "Investment Climate Survey" project. For the same reasons we cannot use the indicators on constitutional rules and judicial independence proposed by La Porta, et al (2004) and on legal procedures suggested by Djankov, et al. (2003). Nor do we not use the composite "governance matters" indicators developed by the World Bank because these, as explained by Kaufmann et al. (2003, p. 31), by construction eliminate the time trend in the data (such as, for instance, a general trend towards more (less) democratic government which clearly would be of interest here). However, the sources for many of these indicators are often the same as those utilized here, so much of the information is taken into account in this study as well.

18 See Appendix 1 for details on how this was done.

19 If necessary we reversed scale of the indicators to have all of them in an increasing order, e.g. we use teacher-pupil ratio instead of the opposite.

4. Constructing composite variables: factor analysis

Given the relatively large number of indicators there is obviously a lot of information to exploit in the analysis. But it goes without saying that it would not be meaningful to take all these indicators on board in, say, a regression analysis on economic growth, since many of them reflect slightly different aspects of the same reality and tend to be highly correlated (hence multicollinearity may be expected). How to combine this information into a smaller number of dimensions with a clear-cut economic interpretation? This is one of the key challenges confronting us in this study.

The most widely used approach to construct composite variables is to use judgment to select the relevant indicators and then weigh these together (normally using equal weights – for survey of the literature see Archibugi and Coco 2005). This requires that we know in forehand which indicators to combine into a single dimension. However, if we lack this knowledge, this way of doing things runs into problems, as appears to be case here. Fortunately there is a well-developed branch of multivariate analysis, so-called "factor analysis" , that is designed to advice on questions like this (Basilevsky 1994). It is based on the very simple idea that indicators referring to the same dimension are likely to be strongly correlated, and that we may use this insight to reduce the complexity of a data set (consisting of many indicators) into a small number of composite variables, each reflecting a specific dimension of the total variance of the data set. This method has been widely used in the social sciences for a long time (Spearman 1904, Hotelling 1933) and was applied to the study of development in the pioneering study by Adelman and Morris (1965, 1967).

Before we move to the factor analysis there are some issues that deserve mentioning. First, the indicators have to be standardized into a common format (deducting mean and dividing by standard deviation) before aggregating them into a composite. We have standardized the indicators with the mean and standard deviation of the pooled data (from the initial and final period). This means that the change of a composite variable over time will reflect both changes in each country's relative position (across countries) and changes in the absolute level of the underlying indicators (over time). In this way we take into account as much information as possible. Second, variables should be relatively evenly distributed, e.g., variables with a "two sample split" (for example very high values for the developed countries and close to zero for the poorer ones) should be avoided and for the same reason outliers need to be dealt with. Simply excluding outliers from the sample may not be the best solution, as we then may lose the important evidence. A log-transformation of the data set was shown to significantly reduce these problems. [20]

Factor analysis is carried out in two steps. First a solution is found in terms of number of factors to be retained and the share of the total variance that these together explain. Then, in a second step, the loadings of the various indicators on the factors are adjusted through so-called "rotation" to maximize the differences between the factors (without changing the number of factors or the share of the total variance that these jointly explain). Hence, the choice of an appropriate method for rotation is obviously an important part of the analysis. For a long time so-called orthogonal rotations, such as "varimax normalized" rotation, were generally preferred in applied work, mainly because these are computationally less demanding than the more complex alternatives. However, orthogonal rotations assume that the underlying composite variables that we are searching for are totally uncorrelated.

20 Some variables containing zeros or negative scale had to be rescaled to positive values. We used a simple rule by adding the minimum observed value in the sample, which delivers the transformation, to all of the observations in the sample.

Although an attractive feature in many respects (not the least in regression analysis) this is a very strong assumption that may be difficult to defend. Arguably, in the real world, there is a good deal of correlation between different social factors, and one would hence like to use a method that allows for that. Moreover, to achieve orthogonality (uncorrelatedness) adjustments in the loadings have to be made that may lead to strange results for individual countries. Therefore we use the more flexible "oblique" rotation, based on the "oblimin" method, which does not from the outset assume orthogonality.

In Table 1 we present the results from a factor analysis on pooled data for the initial and final period for the 115 countries covered by the analysis (therefore 230 observations). The table presents the factor loadings (e.g. correlations between the indicators and the retained factors) after oblimin oblique rotation. The analysis led to the selection of four principal factors jointly explaining 74% of the total variance.[21] The first factor, which explains about one third of the total variance, correlates highly with several indicators associated with "technological capability" and "absorptive capacity" such as R&D, patenting, scientific publications, ICT infrastructure, ISO 9000 certifications and availability of finance. However, it also correlates highly with education, so it cuts across the established distinction between "technological" and "social" capabilities. We suggest interpreting it as a synthetic measure of the quality of a country's *"innovation system"*. Figure 2 plots the factor score on innovation system against GDP per capita (as a measure of the level of economic development). The first thing to note is the very tight correlation between the two, the quality of the innovation system "explains" more than 85 % of the variation in development. To the extent that there are some deviations from the regression line it comes from a group of resource rich economies (OPEC countries for instance), having slightly higher GDP per capita levels than the quality of their innovation systems would indicate, and a group of the former centrally-planned economies for which it is the other way around.

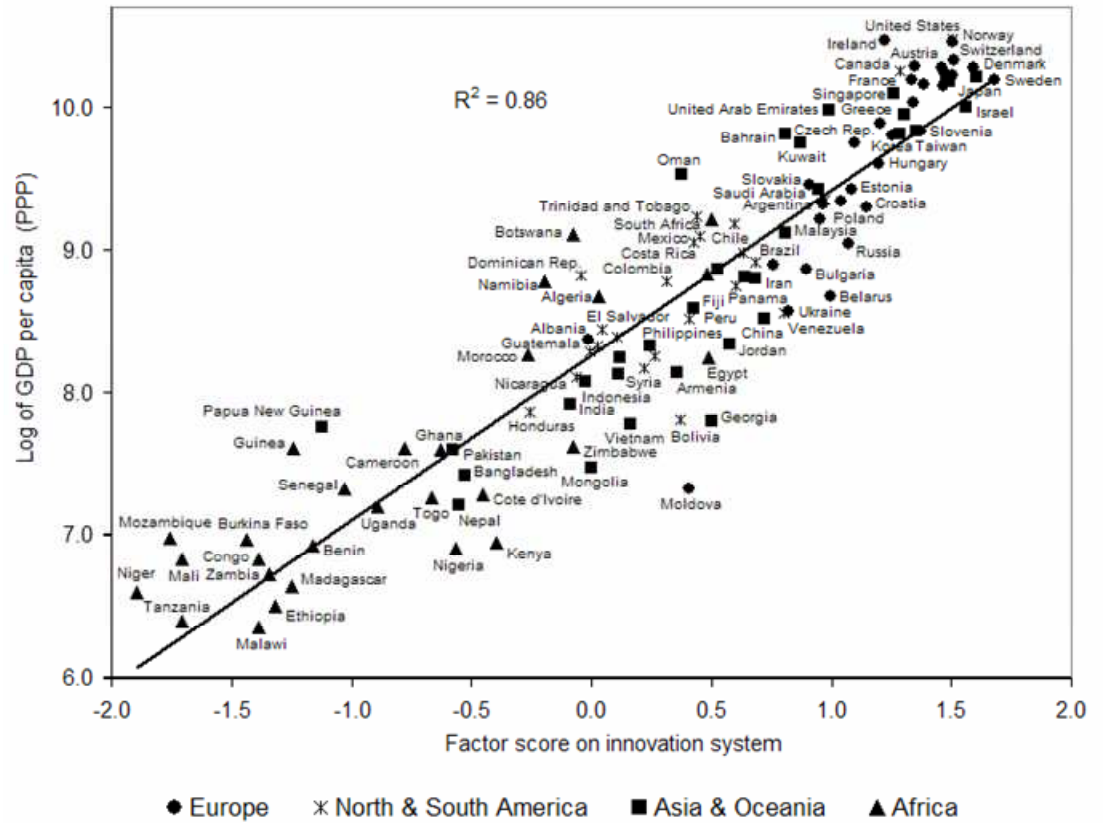
21 The method "principal component factors" (Stata 9.2) was used. This method returns as many factors as indicators, e.g., 25. Factors with an eigenvalue above unity were retained for the second step of the analysis. This means that factors that explained less than an "average indicator" (1/25 = 4%) were dropped. The choice of four factors was also found to be consistent with a Scree-test. An alternative method for identifying factors is based on the Maximum Likelihood approach. This method has the advantage that it has provides significance test for each factor. However, the method is known in many cases to converge to a corner solution (Heywood solution) in which case these tests are not valid (which happened in the present case).

Table 1
Results of factors analysis

	Innova-tion system	Gover-nance	Political system	Openness
Research and development expenditure (% of GDP)	0.72	0.18	-0.08	-0.33
USPTO patents (per capita)	0.63	0.32	0.14	-0.06
Science & engineering articles (per capita)	0.64	0.40	0.06	-0.11
ISO 9000 certifications (per capita)	0.80	0.04	0.00	0.29
Fixed line and mobile phone subscribers (per capita)	0.92	-0.00	0.05	0.11
Internet users (per capita)	0.78	-0.17	0.09	0.36
Personal computers (per capita)	0.77	0.17	0.01	0.21
Primary school teacher-pupil ratio	0.82	0.15	-0.08	-0.15
Secondary school enrolment (% gross)	0.93	-0.09	0.04	-0.11
Tertiary school enrolment (% gross)	0.94	-0.11	0.10	-0.14
Domestic credit to private sector (% of GDP)	0.48	0.44	0.00	0.09
Market capitalization of listed companies (% of GDP)	0.42	0.33	0.06	0.26
Merchandise imports (% of GDP)	-0.08	0.04	-0.15	0.71
Foreign direct investment inward stock (% of GDP)	0.02	0.02	0.08	0.86
Impartial courts	-0.07	0.86	-0.04	-0.10
Law and order	0.22	0.58	-0.07	-0.01
Property rights	-0.01	0.88	0.16	0.02
Regulation	0.10	0.72	0.05	0.02
Informal Market (corruption)	0.26	0.68	-0.03	0.23
Index of democracy and autocracy	-0.03	-0.03	0.96	-0.05
Political constraint	0.07	0.03	0.81	0.00
Legislative index of political competitiveness	-0.03	-0.19	0.84	0.01
Executive index of political competitiveness	0.10	-0.24	0.83	0.01
Political rights	-0.01	0.23	0.89	-0.02
Civil liberties	0.01	0.27	0.82	0.04
Explained percentage of total variance	30.0	20.0	17.8	6.6

Note: Four factors with eigenvalue > 1 were detected, which explain 74.4% of total variance; extraction method: principal components factors; rotation: oblimin oblique. Number of observations = 230 (pooled data for 115 countries in the initial and final period).
Source: See Appendix 1.

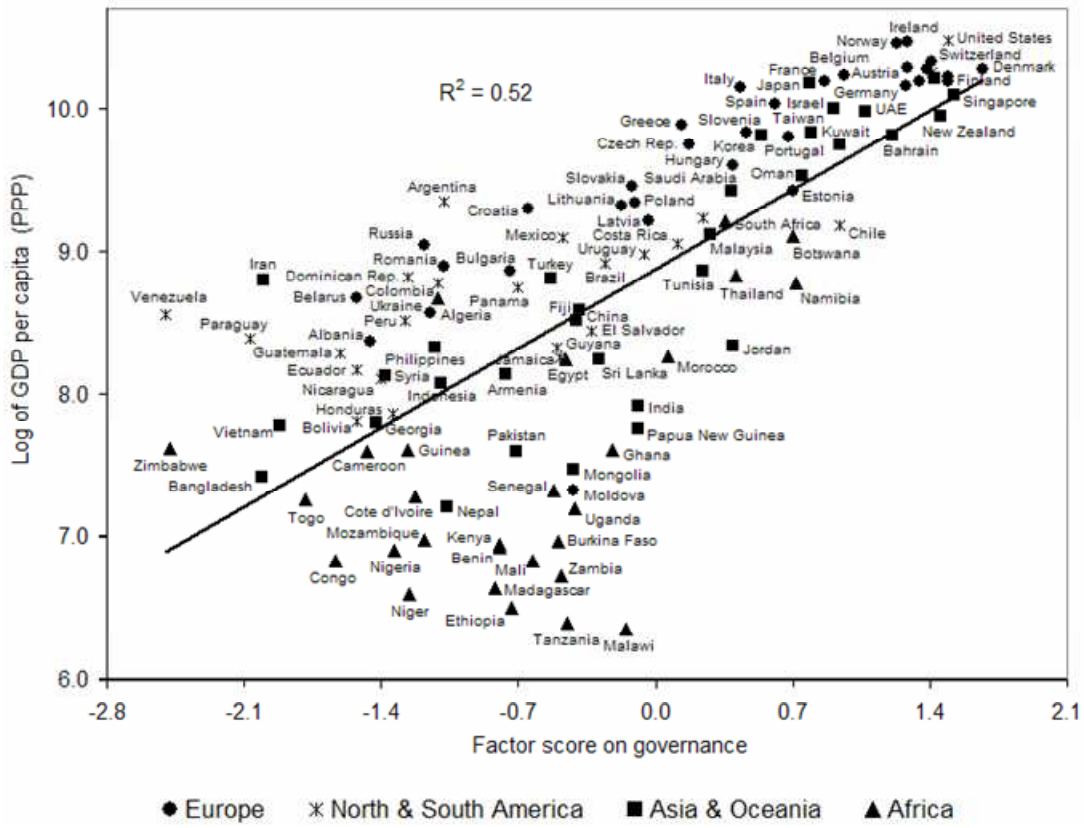
Figure 2
GDP per capita and innovation system (average level over 2002-2004)



Note: For definition of the innovation system variable see Table 1.
Source: See Appendix 1.

A brief look at the next two factors, which each explains about one fifth of the total variance, reveals that the above mentioned difference between "governance" (or "policy") on the one hand and "rules of the game" (or "institutions") on the other are clearly mirrored in the results. The second factor loads high on various aspects reflecting the quality of "*governance*", such as a well-functioning judicial system, little corruption and a favourable environment for new businesses. As in the previous case this factor score correlates positively with the level of economic development (and significantly so). However, as is evident from Figure 3, the relationship is not as strong as in the case of the innovation system. The main reason for this is that there is a group of countries, mainly of African origin, that deviates from the main pattern by being much poorer than the quality of governance should indicate.

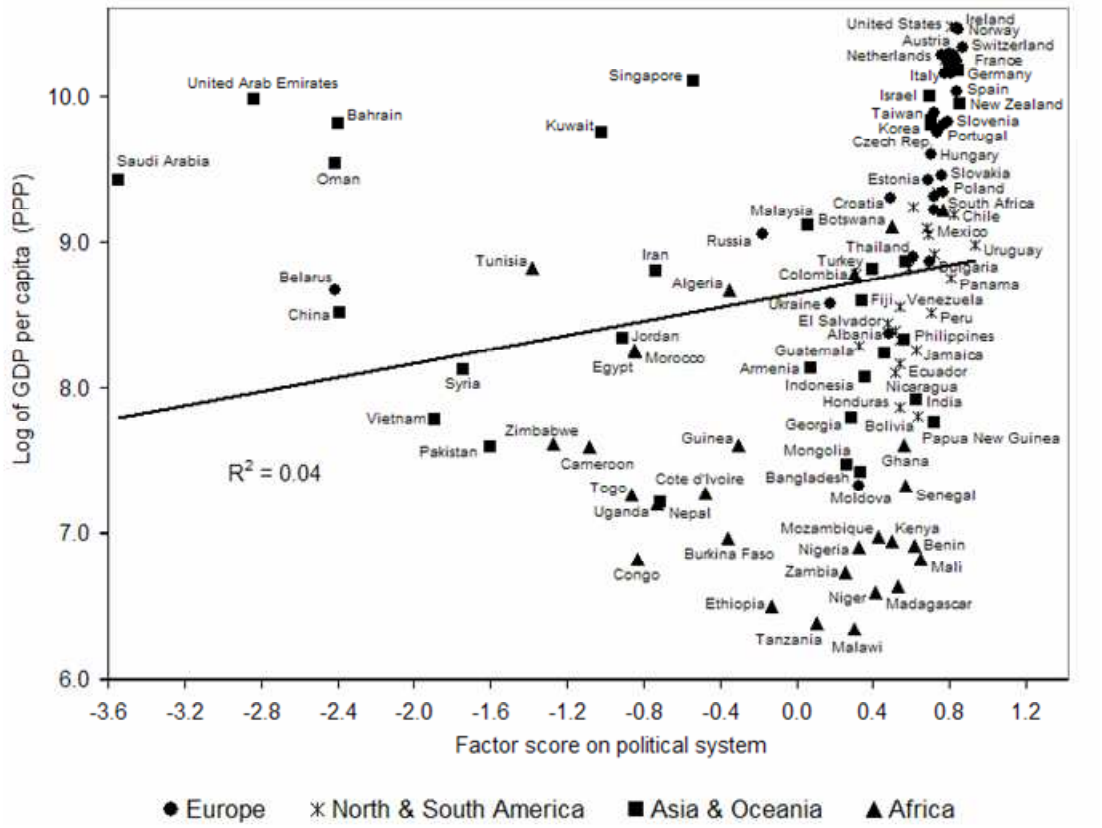
Figure 3
GDP per capita and governance (average level over 2002-2004)



Note: For definition of the governance variable see Table 1.
Source: See Appendix 1.

The third factor, in contrast, loads particularly high on a number of aspects reflecting the character of the *"political system"* (e.g., "rules of the game"). In short, countries with political systems that are close to those of the Western world, rank high on this dimension, while countries with systems that differ lot from Western democratic ideals, get a low mark. In contrast to the innovation system variable, however, the character of the political system is not closely correlated with levels of economic development. In fact, figure 4 reveals that some countries with distinctly "non-Western" (authoritarian) regimes do rather well economically. However, most countries cluster to the right in the figure (indicating a "Western" type political system) irrespective of their level of economic development.

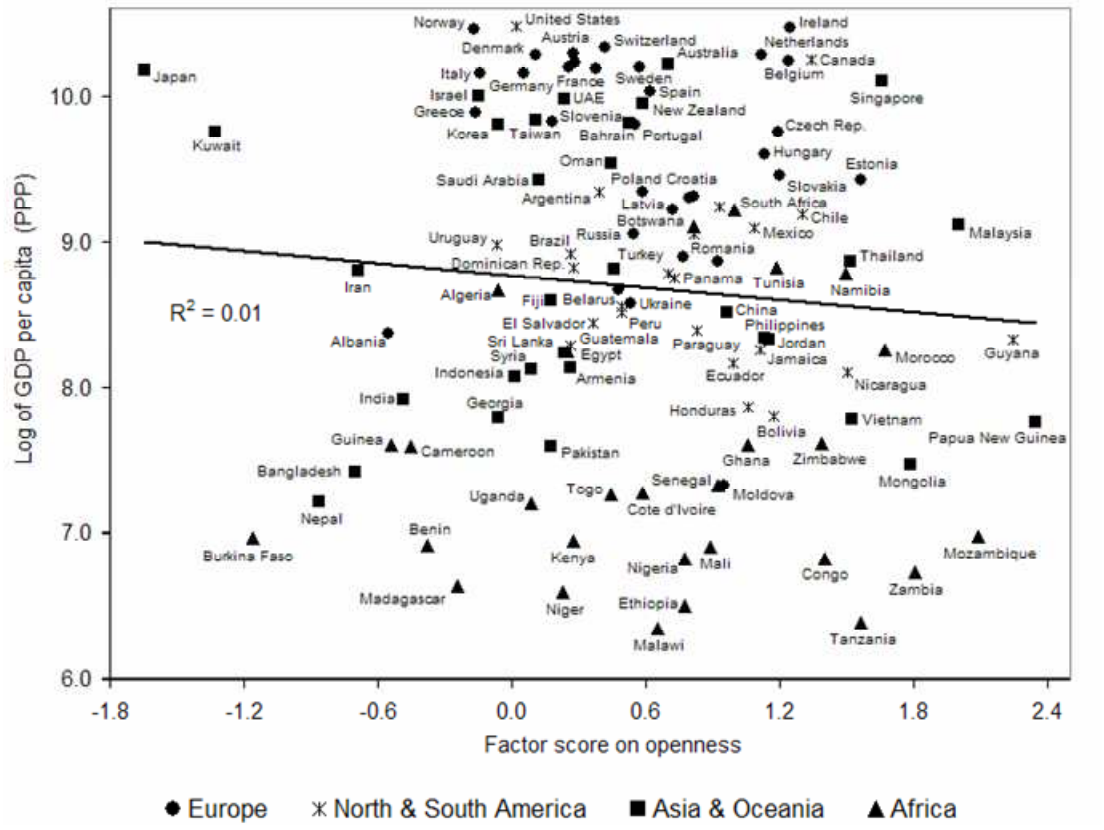
Figure 4
GDP per capita and political system (average level over 2002-2004)



Note: For definition of the political system variable see Table 1.
Source: See Appendix 1.

Finally, there is a fourth factor which may be labelled "*openness*" as it shows high correlation with imports and inward FDI. Hence this factor picks up aspects that (in at least some versions of the arguments) are attributed to "absorptive capacity". As noted this is a factor that is deemed especially important by followers of the "new growth theory". However, this fourth factor contributes much less to the explanation of the total variance than do the three other factors (only about seven per cent). Nor is the composite variable based on this factor closely correlated with economic development in Figure 5. However, it is nevertheless important to retain this factor because the results confirm that it captures a distinct aspect of reality (which may help to improve our understanding of the other factors as well).

Figure 5
GDP per capita and openness (average level over 2002-2004)



Note: For definition of the openness variable see Table 1.
Source: See Appendix 1.

Although most indicators correlate with one composite variable only there are a few exceptions worth noting. For instance, supply of credit to the private sector correlates moderately with both Innovation System and Governance. This is not necessarily surprising. A well functioning banking system is obviously important for innovation, but it is arguably also intimately related to good governance. Scientific articles correlate highly with the Innovation system and (moderately) with Governance. The latter may be explained by the fat that most scientific articles originate from public sector organisations or private research sponsored by the public sector. Thus, the results indicate that although the quality of the Innovation System and that of Governance represent different aspects of reality (and it is possible to distinguish clearly between them) there is also to some extent a relationship between the two. The spread of internet correlates highly with the innovation system and moderately with Openness. The former clearly concords with our hypotheses but the latter makes sense too. Arguably, openness (in an economic sense) should not only be about flows of goods and money across borders but also about flows of *ideas* (for which internet access comes in very handy).

5. Capabilities and development

To sum up the main findings so far, there appears to be a very strong relationship between the innovation system and the level of development, and the same holds to some extent for the relationships between governance and development. In contrast, openness and the character of the political system appear not to be strongly related to economic development, at least not

as measured here. However, such simple correlations may mask more complex relationships, so in a second step we carry out a multivariate regression of the relationship between the four capabilities previously identified and the level of economic development as reflected by GDP per capita. To avoid simultaneity bias in the estimates we use data from the initial period (average 1992-1994) for the four capabilities and the final period (average 2002-2004) for GDP per capita.

As is customary in the literature we include, in addition to the capabilities mentioned above, a battery of indicators reflecting differences in geography, nature and history. After a screening of the recent literature on the role of such exogenous factors for growth (Acemoglu, et al. 2002, Alesina, et al. 2003, Bloom, at al. 2003, Fearon 2003, Gallup, et al. 1999, Masters and McMillan 2003, Sachs, et al. 2004), the following fourteen variables were selected: longitude of country centroid, latitude of country centroid, log of surface area, access to ocean, land in desert ecozone, land in tropical ecozone, log of population density, ethnic fractionalization, religion fractionalization, malaria fatal risk, log of oil deposits per capita, mean soil suitability for rain fed crops, log of the number of people killed in natural disasters per capita and log of years since national independence (see Appendix 1 for details). We use a (backward) stepwise regression to identify the specification with the best statistical properties.[22] To test for the robustness of the results with respect to the composition of the sample we re-estimate this relationship with a robust regression technique, iteratively reweighted least squares. [23]

Table 2 presents the results from the regression analysis. Note that all variables are expressed in a common scale (standardized by deducting the mean and dividing by the standard deviation), which allows for direct comparisons of parameter values (beta coefficients are reported).[24] The main result is that irrespective of choice of econometric method the development of the *"innovation system"* and the quality of *"governance"* are positively and significantly associated with economic development. For the two remaining capabilities there is no significant relationship. The introduction of indicators reflecting differences in nature, geography and history led to a slight increase in the explanatory power of the model and a slight decrease in the correlation between GDP per capita and the development of the Innovation System. Hence, these results confirm earlier findings that such differences do matter for economic development. Moreover, the results reached here indicate that one important reason for this may be that these differences influence the ability of a country to develop a well-functioning innovation system.

22 The aim of the stepwise procedure (*stepwise reg* command in Stata 9.2) is eliminate (insignificant) variables that do not contribute to the explanatory power of the model (given a chosen significance level). At each step the stepwise method also attempts to reintroduce already eliminated variables to control for a possibility that some of them might become significant later on. We specified the threshold for removal at 20% significance and the level for reintroducing a variable at 15%.

23 Iteratively reweighted least squares is a robust regression technique, which assigns a weight to each observation, with lower weights given to outliers (*rreg* command in Stata 9.2).

24 See Wooldridge (2002a, pp. 114-115). Another effect of the standardization is that sample average is equal to zero, which implies that in the OLS estimate by definition, the constant term equals zero as well.

Table 2
Regression results – levels

	(1)	(2)	(3)
Estimation method	OLS	Stepwise regression with fixed factors	Iteratively re-weighted least squares
Intercept	..	..	0.003
	..	..	(0.11)
Innovation system	0.84***	0.70***	0.75***
	(19.60)	(15.56)	(17.68)
Governance	0.17***	0.19***	0.15***
	(3.70)	(4.49)	(4.18)
Political system	-0.03	..	..
	(0.82)	..	..
Openness	0.04	..	..
	(1.32)	..	..
Longitude of country centroid	..	-0.06***	-0.06**
	..	(2.84)	(2.06)
Access to ocean	..	0.09***	0.10***
	..	(3.62)	(3.39)
Oil deposits	..	0.07**	0.07**
	..	(2.54)	(2.40)
Ethnic fractionalization	..	-0.11***	-0.08**
	..	(3.37)	(2.40)
Natural disasters	..	-0.04**	-0.04
	..	(2.22)	(1.33)
F	366.22	260.08	186.81
R^2	0.91	0.93	..
Observations	115	115	115

Note: Depended variable is log of average GDP per capita over 2002-2004 (PPP, constant 2000 USD). The independent variables of capabilities (factor scores) are their lagged levels from the period 1992-1994. Absolute value of robust t-statistics in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels. Standardized variables used in the estimates (beta coefficients reported).

In the discussion so far we have mainly examined the relationship between capabilities and development when measured in levels. However, can the results from the above analysis, e.g., the importance of the development of the Innovation System and the quality of Governance for economic development, be sustained in a dynamic framework (e.g., explain differences in economic growth)? It is worth noting that many contributions to the empirical literature on cross-country differences in growth performance, despite theoretical differences, share a common empirical framework. This framework, so-called Barro-regressions (Barro 1991), consists of regressing economic growth against initial GDP per capita and a number of other factors that may be deemed relevant (for a cross-country sample). In this framework the GDP per capita variable measures the potential for catch-up (or convergence). The other variables represent factors that are assumed to be of importance for (or "condition") the ability to exploit this potential. Hence in the literature these factors are often dubbed "conditional factors", and the growth-regressions with these factors included are interpreted as tests of so-called "conditional convergence".[25] We shall apply this framework here. As

25 The first to introduce this technique to the study of growth and development was probably John Cornwall (1976). Cornwall used GDP per capita to measure the gap in technology between frontier and the late-comer countries. The higher this gap, he pointed out, the higher the potential for high growth in late-comer countries through successful imitation of superior technology developed elsewhere. However, in his view, to exploit this

conditional factors we include the capabilities developed in this paper and the battery of indicators reflecting exogenous factors related to geography, nature and history.

Table 3 presents the results from the analysis. The first model (1) regresses the potential for catch-up (log of initial GDP per capita) and the *changes* in the capabilities on growth of GDP per capita. The development of the innovation system and the change in the quality of governance from the preceding period were found to be highly significant, positive predictors of growth while the changes in the political system and openness were found to be uncorrelated with growth. However, the effect of the GDP per capita variable was not significant following traditional statistical criteria (5% level) and positive, e.g., indicating - if anything - "conditional divergence". The model also predicts poorly. The second model (2) adds the initial *levels* of the capabilities along with their changes as possible "conditional factors". In this set up both the level and change of the development of the innovation system and the quality of governance were found to be positive and significant predictors of growth, while as before the two remaining capabilities were found not to matter much. Moreover, the GDP per capita becomes significant and with the right sign. The explanatory power of the model increases significantly as well.

In the third model (3) we add the fourteen exogenous variables previously introduced, reflecting differences in nature, geography and history. As earlier we use a (backward) stepwise regression procedure to identify the model with the best statistical properties. Again, a healthy increase in the explanatory power of the model can be recorded, confirming our earlier result that such exogenous factors do indeed matter for development. However, with these exogenous factors included the level of the innovation system is not any longer a significant factor for growth, and the estimated impact of the changes in this level on growth is also much reduced (although still positive and significant). Hence, these results lend further support to our previous finding that, say, unfavourable factors related to nature, geography and history tend to hamper the development of well-working innovation system and with it the level of economic development more generally.

To test for a potential endogeneity bias in the estimates, due to a possible feedback from economic growth (the dependent variable) on capability changes, we applied the Hausman (or Durbin–Wu–Hausman) test for endogeneity.[26] This test is performed by first regressing each potentially endogenous explanatory variable on all exogenous variables (and instruments), and then, in a second step, including the residuals from these regressions as additional variables in a new regression of the original model.[27] If some of the residuals come out as significant in this latter regression, we accept endogeneity of the variable and the model should be estimated by, say, two-stages least squares in order to obtain consistent results. However, in the present case the test failed to provide evidence for such endogeneity problems .

In the fourth and fifth columns we test for the robustness of the "best model" with respect to changes in the composition of the sample. The fourth model (4) applies, as before, a robust regression technique (iteratively reweighted least squares) while in the fifth model (5) twenty-five countries with political systems deviating a lot from Western ideals were

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gap countries needed to do additional investments (and that is where the "conditional" aspect comes in). See Fagerberg (1994) for an extended discussion.

26 For further details see Wooldridge (2002b, pp 118-122).

27 The exogenous variables that were excluded from the "best" model by the stepwise regression were used as instruments in the test.

removed. The results indicate that the results reported in the third model for the political system and openness variables are not robust to changes in the sample. The conclusion, therefore, must be that for these two variables there is not convincing evidence for a systematic relationship with economic growth, even when the impact of other variables have been accounted for. [28]

Table 3
Regression results – growth

	(1)	(2)	(3)	(4)	(5)
Model	Basic model	Initial levels	Stepwise regression with fixed factors	Iteratively re-weighted least squares	OLS excl. outliers (political system)
Intercept	..	..	..	0.02	..
	..	..	..	(0.33)	..
Log of the initial GDP per capita	0.15*	-0.83**	-0.53***	-0.55***	-0.65***
	(1.91)	(2.31)	(2.97)	(3.59)	(2.79)
Innovation system	..	0.78**	..	..	..
	..	(2.38)	..	..	..
Governance	..	0.36***	0.33**	0.36***	0.45**
	..	(2.64)	(2.27)	(2.83)	(2.44)
Political system	..	0.06	-0.22**	-0.23**	0.02
	..	(0.58)	(1.87)	(2.18)	(0.17)
Openness	..	0.10	0.18**	0.11	0.19
	..	(0.96)	(2.11)	(1.25)	(1.63)
Δ innovation system	0.31***	0.45***	0.24***	0.28***	0.23**
	(3.50)	(4.69)	(2.88)	(3.25)	(2.40)
Δ governance	0.36***	0.35***	0.33***	0.42***	0.28**
	(3.74)	(3.58)	(3.11)	(5.30)	(2.07)
Δ political system	0.10	0.12	..	..	..
	(1.38)	(1.33)	..	..	..
Δ openness	0.03	0.05	..	..	..
	(0.25)	(0.33)	..	..	..
Latitude of country centroid	..	..	0.12	0.13	0.16**
	..	..	(1.58)	(1.51)	(2.01)
Ethnic fractionalization	..	..	-0.26***	-0.16*	-0.23**
	..	..	(2.43)	(1.70)	(2.01)
Malaria fatal risk	..	..	-0.37**	-0.44***	-0.39**
	..	..	(2.56)	(3.58)	(2.34)
Land in desert ecozone	..	..	-0.32***	-0.34***	-0.12
	..	..	(3.63)	(3.73)	(1.34)
Natural disasters	..	..	-0.16***	-0.14*	-0.23***
	..	..	(3.03)	(1.82)	(2.72)
F	5.25	4.26	6.76	9.05	6.44
R^2	0.20	0.31	0.42	..	0.41
Observations	115	115	115	115	90

Note: Depended variable is annual growth of GDP per capita (PPP, constant 2000 USD) over 1992-2004. Absolute value of robust t-statistics in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels. Standardized variables used in the estimates (beta coefficients reported).

6. Concluding remarks

The point of departure of this paper has been the finding that income gaps in the global economy are widening rather than narrowing. In fact, historical research shows that this is a long run trend. However, there have always been examples of countries that have defied the trend and managed to catch up with the much richer countries at the technology frontier, and this also holds for the period under investigation here. The reasons for this have been a matter of considerable controversy, though.

However, in recent years the quality and availability of data on different aspects of development have improved a lot, and this might give researchers in this area an opportunity for investigating the reasons behind the large differences in economic performance in more depth. Attempting to exploit this opportunity this paper starts with an overview of the different approaches in the literature to the explanation of these differences and in particular the empirical indicators and methods that these different approaches have highlighted. This led to the formulation of a synthetic empirical model and, with the help of factor analysis, the identification of set of "capabilities" which might be assumed to be of critical importance for catch up.

The following "capabilities" were identified and measured with the help of data for twenty-five different variables for 115 countries over the 1992-2004 period:

The development of the *"innovation system"*
The quality of *"governance"*
The character of the *"political system"*
"Openness" to technology/knowledge from abroad

The first of these, *"innovation system"*, is a synthetic measure of some of the most critically important capabilities required in the global knowledge based economy. It includes such things a skilled labour force, R&D resources, a well-developed ICT infrastructure and access to finance. The analysis conducted here suggests that a well developed "*innovation system"* is a must for countries that wish to succeed in catch up. There is a strong, significant and robust statistical relationship between (level and change of) GDP per capita on the one hand, and (level and change of) the "*innovation system"* on the other. Historical and descriptive evidence also suggest that countries that have succeeded in catch up have given a high priority to this dimension of development.

Albeit a well developed "*innovation system"* emerges from the analysis as a clear priority no. 1 for development, it is not sufficient. A well developed "*innovation system"* needs to be backed by good "*governance"* to succeed. Sometimes it is asserted that this is mainly a question of successfully "westernising" the political system, e.g., adapting to institutional arrangements that have proved to be successful in the United States and other western democracies. This study finds the support for these assertions to be rather weak. What is required, it seems, is the ability to continuously improve the "*innovation system"* and the quality of *"governance"* through the mobilization of human, financial and administrative resources, and this appears to have been possible in countries with quite different institutional arrangements. This conclusion does not only rest on statistical evidence but is also supported by historical research (consider for instance the recent performance of countries such as China and Vietnam, the Asian Tigers before the 1990s or pre-world-war-two Japan). Hence, the available econometric evidence seems to confirm what follows from casual observation, namely that the political and legal systems of successful countries (and unsuccessful ones as well) can differ a lot.

Another result from the study, consistent with previous research by Rodrik et al. (2004), is that there is little support for the argument that differences in "openness" matter a lot for development. This holds even, as in the present case, when country size was controlled for. This finding clearly runs counter to arguments based on "new growth theories" emphasizing the openness dimension as perhaps the single most important one for development. Note, however, that the results reached here does not necessarily invalidate the argument, central to these theories, that flows of ideas across borders are important for global growth. What the results imply, perhaps, is that what matters for performance is not so much differential access to such flows as the ability to take advantage of them. Arguably this is an issue that may require further research.

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Appendix 1 (data & sources)

A brief overview of definitions, sources and time/country coverage of the indicators is given in the table below. The main source of data is the World Bank (World Development Indicators 2006), which combines various sources of data for a large sample of countries. The database has been complemented by data from other organizations such as UNESCO, UNCTAD, OECD, ISO, ITU, Heritage Foundation and others, and in addition datasets produced by research projects. National sources were only used for Taiwan if necessary and in a few cases for R&D data from developing countries.

We originally collected data for all independent states (app. 175 countries) and a large pool of indicators (app. 100 indicators). The screening revealed that a group of (mostly least developed) countries suffers from a lot of missing data. Similarly data for a large number of relevant indicators are available only for a group of high (medium) income countries and/or only for the most recent period. A closer look, furthermore, revealed that some indicators suffer from high volatility (primarily in developing world), methodological changes over the period or are merely variations of each other. These indicators were then skipped. In order to strike a balance between the need to bring rich evidence for as many countries as possible and data availability and methodological coherence, we selected 115 countries (see Appendix 2 for the full list of countries) and twenty-five indicators on capabilities (plus the fourteen „exogenous factors" reflecting differences in geography, nature and history). We use the indicators in the form of three-year averages (1992-1994 and 2002-2004) to limit influence of shocks and measurement errors occurring in specific years.

Although the selected indicators have broad coverage, in some cases there were missing values that had to be dealt with. Missing values were most frequent for R&D expenditure, personal computers, the teacher-pupil ratio, market capitalization of listed companies and some of the governance indicators. A number of developing countries were not included in the early surveys of computers and Internet penetration. We assumed that the initial value was zero if these series started from less than one per mil. people later during the nineties (six observations for computers and eighteen observations for Internet). Some missing data on the market capitalization were filled by collecting information on Stock Markets of the World (www.escapeartist.com/stock/markets.htm). Countries without a stock market in a given period were given zero (a total of forty-five observations). The remaining missing data were estimated using the *impute* procedure in Stata 9.2 (see the Stata 9 Manual for details). We based the estimation on data for other indicators in the dataset. The proportion of data estimated by the procedure is given in the last column of the following table.

It should be stressed that considerable care was taken to check the estimated data against observed figures in countries with similar characteristics (level of development, region, history, etc.). In a few cases the estimated data would exceed the minimum observed value of an indicator elsewhere. In such cases we truncated the data by replacing the estimated values by the minimum observed figure. Only data from 1993 onwards were used for the science and engineering articles for the former Soviet Union and Yugoslavia countries due to problems of reporting in the early 1990s. We also reversed the scale, while keeping the original range, for some indicators of governance and political system in order to have the indicator in increasing order (with low value signalling weak governance and vice versa). Note that this change of scale does not alter any property of the data but simplifies the interpretation of loadings in the factor analysis.

Indicator & definition	*Scaling*	*Source*	*Average over period*	*% of data estimated*
Gross Domestic Product (GDP): GDP converted to (constant 2000) international USD using purchasing power parity rates (PPP).	per capita	World Bank (World Development Indicators 2006)	1992-1994 & 2002-2004	0
Research and development expenditure (R&D): Total (public and private) intramural expenditure on research and experimental development performed on the national territory.	% of GDP	World Bank (World Development Indicators 2006), OECD (MSTI Database), UNESCO (S&T Statistics), RICYT and national sources	1992-1994 & 2002-2004	31
USPTO patents: Number of utility patents (patents for invention) granted by the U.S. Patent and Trademark Office (USPTO). The origin of a patent is determined by the residence of the first-named inventor.	per capita	USPTO	1992-1994 & 2002-2004	0
Science & engineering articles: Counts of articles published in journals classified and covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). The article counts are based on fractional assignments.	per capita	U.S. National Science Foundation (Science and Engineering Indicators 2006)	1992-1994 & 2002-2003	0
ISO 9000 certifications: A family of standards approved by the International Standards Organization (ISO) that define a quality management and quality assurance program.	per capita	International Organization for Standardization (The ISO Surveys of ISO 9000 Certificates)	1992-1994 & 2002-2003	0
Fixed line and mobile phone subscribers: Telephone mainlines connecting a customer's equipment to the public switched telephone network (PSTN) and users of portable telephones that subscribe to an automatic public mobile telephone service by cellular technology providing access to the PSTN.	per capita	World Bank (World Development Indicators 2006), ITU (World Telecommunication Indicators Database 2005)	1992-1994 & 2002-2004	0
Internet users: Internet users are people with access to the worldwide network.	per capita	World Bank (World Development Indicators 2006), ITU (World Telecommunication Indicators Database 2005)	1994 & 2002-2004	1
Personal computers: Computers designed to be used by a single individual.	per capita	World Bank (World Development Indicators 2006), ITU (World Telecommunication Indicators Database 2005)	1994 & 2002-2004	9
Primary school teacher-pupil ratio: The number of primary school teachers (regardless of their teaching assignment) divided by the number of pupils enrolled in primary school.	ratio	World Bank (World Development Indicators 2006), UNESCO (Global Education Digest 2005)	1991 & 2002-2004	11
Secondary school enrolment: The ratio of the number of secondary students of all ages (gross) expressed as a percentage of the secondary school-age population.	% gross	World Bank (World Development Indicators 2006), UNESCO (Global Education Digest 2005)	1991 & 2002-2004	3
Tertiary school enrolment: The ratio of the number of tertiary students of all ages (gross) expressed as a percentage of the tertiary school-age population.	% gross	World Bank (World Development Indicators 2006), UNESCO (Global Education Digest 2005)	1991 & 2002-2004	3

Domestic credit to private sector: Financial resources provided to the private sector, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	% of GDP	World Bank (World Development Indicators 2006)	1992-1994 & 2002-2004	0

Market capitalization of listed companies: The share price times the number of shares outstanding (also known as market value) of domestically incorporated companies listed on the country's stock exchanges at the end of the year.	% of GDP	World Bank (World Development Indicators 2006)	1992-1994 & 2002-2004	4
Merchandise imports: The c.i.f. value of goods received from the rest of the world. Goods simply being transported through a country (good in transit) or temporarily admitted (except for goods for inward processing) are not included.	% of GDP	World Bank (World Development Indicators 2006)	1992-1994 & 2002-2004	0
Foreign direct investment (FDI) inward stock: A received investment that involves a long-term relationship and reflects a lasting interest in and control by a resident entity in one economy of an enterprise resident in a different economy.	% of GDP	UNCTAD (FDI Database 2005)	1992-1994 & 2002-2003	1
Impartial courts: The degree to which a trusted legal framework exists for private businesses to challenge the legality of government actions or regulation.	index (0 to 10)	Gwartney and Lawson (2004) - based on the WEF (Global Competitiveness Report, various issues)	1995 & 2002-2003	8
Law and order: The degree to which the citizens of a country are willing to accept the established institutions, to make and implement laws and adjudicate disputes.	index (0 to 10)	PRS Group (International Country Risk Guide, various issues) – data retrieved from Henisz (2005)	1992-1994 & 2002-2004	8
Property rights: The degree to which a country's laws protect private property rights and the degree to which its government enforces those laws. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 5)	Heritage Foundation (Index of Economic Freedom, various issues) - based on the Economist Intelligence Unit (Country Commerce and Country Reports)	1995 & 2002-2004	1
Regulation: How easy or difficult it is to open and operate a business. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 5)	Heritage Foundation (Index of Economic Freedom, various issues) - based on the Economist Intelligence Unit (Country Commerce and Country Reports)	1995 & 2002-2004	2
Informal Market: The perceptions of people with regard to the extent of corruption, defined as the misuse of public power for private benefit. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 5)	Heritage Foundation (Index of Economic Freedom, various issues) - based on the Transparency International (Corruption Perceptions Index)	1995 & 2002-2004	1
Index of democracy and autocracy: The degree of autocracy versus democracy in increasing order (POLITY2 variable).	index (-10 to 10)	Marshall and Jaggers (2003)	1992-1994 & 2002-2003	0
Political constraint: The extent to which a change in the preferences of any one actor may lead to a change in government policy (POLCONIII variable).	index (0 to 1)	Henisz (2002, 2005)	1992-1994 & 2002-2004	0
Legislative index of political competitiveness: Competitiveness of elections into legislative branches (LIEC variable).	index (1 to 7)	Beck, et al. (2001) and Keefer (2005)	1992-1994 & 2002-2004	0

Executive index of political competitiveness: Competitiveness for post in executive branches in government (EIEC variable).	index (1 to 7)	Beck, et al. (2001) and Keefer (2005)	1992-1994 & 2002-2004	0

Political rights: The degree to which people participate freely in the political process derived from standards by the Universal Declaration of Human Rights. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 7)	Freedom House (Index of Freedom in the World, various issues)	1992-1994 & 2002-2004	0
Civil liberties: The degree of the freedoms of expression and belief, associational and organizational rights, rule of law, and personal autonomy without interference from the state derived from standards by the Universal Declaration of Human Rights. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 7)	Freedom House (Index of Freedom in the World, various issues)	1992-1994 & 2002-2004	0
Longitude of country centroid: Longitude is measured from the Prime Meridian with positive values going east and negative values going west.	degrees	Gallup, et al. (1999) - CID Geography Datasets	Fixed factor	0
Latitude of country centroid: Latitude is measured from the equator, with positive values going north and negative values going south.	degrees	Gallup, et al. (1999) - CID Geography Datasets	Fixed factor	0
Surface area: Country's total area, including areas under inland bodies of water and some coastal waterways.	Log of km^2	World Bank (World Development Indicators 2006)	Fixed factor	0
Access to ocean: Proportion of land within 100 km of the ocean coastline, excluding coastline in the arctic and sub-arctic region above the winter extent of sea ice.	%	Gallup, et al. (1999) - CID Geography Datasets	Fixed factor	0
Land in desert ecozone: Proportion of land in (temperate or tropical) desert ecozone.	%	Gallup, et al. (1999) - CID Geography Datasets – based on the UNEP	Fixed factor	0
Land in tropical ecozone: Proportion of land in tropical ecozone.	%	Gallup, et al. (1999) - CID Geography Datasets – based on the UNEP	Fixed factor	0
Population density: Midyear population divided by land area.	Log of people per km^2	World Bank (World Development Indicators 2006); missing data filled from UNEP (The GEO Data Portal)	1992-2004	0
Malaria fatal risk: Proportion of population at risk of contracting falciparum malaria.	%	Earth Institute (Jeffrey D. Sachs Malaria Dataset)	1996	0
Ethnic fractionalization: The probability that two randomly selected people from a given country will not belong to the same ethic group.	index (0 to 1)	Alesina, et al. (2003)	The latest available	0
Religion fractionalization: The probability that two randomly selected people from a given country will not belong to the same religion.	index (0 to 1)	Alesina, et al. (2003)	The latest available	0
Oil deposits: Proven crude oil reserves in billion barrels (bbl).	log of (bbl +1) per capita	The CIA World Factbook 2005	The latest available	0
Mean soil suitability for rainfed crops: Mean proportion of each soil type that is moderately or very suitable for each of six rainfed crops.	%	Gallup, et al. (1999) - CID Geography Datasets	Fixed factor	0
Killed in natural disasters: Number of persons killed (confirmed as dead, missing and presumed dead) in disasters of natural origin (droughts, earthquakes, extreme temperatures, floods, slides, waves, wind storms, etc.).	log of killed per capita	UNEP (The GEO Data Portal) – based on the OFDA/CRED International Disaster Database 2004	1992-2004	0

National independence: Number of years since gaining national independence over the period 1816-2004 (maximum truncated at 188 years).	Log of years	Fearon (2003); missing data filled from the CIA World Factbook	1816-2004	0

Appendix 2 (factor scores)

	Innovation system		Governance		Political system		Openness	
	1992-1994	2000-2004	1992-1994	2000-2004	1992-1994	2000-2004	1992-1994	2000-2004
Developed Countries								
Australia	0.9	1.6	1.4	1.4	0.8	0.8	0.3	0.7
Austria	1.0	1.4	1.4	1.3	0.7	0.8	-0.8	0.3
Belgium	0.9	1.5	1.3	1.0	0.8	0.8	0.5	1.2
Canada	1.0	1.3	1.6	1.4	0.7	0.8	0.5	1.3
Denmark	1.0	1.6	1.6	1.7	0.8	0.8	-0.9	0.1
Finland	1.2	1.5	1.2	1.5	0.8	0.8	-0.9	0.3
France	1.1	1.3	1.2	0.9	0.6	0.8	-0.6	0.4
Germany	1.0	1.4	1.6	1.3	0.7	0.8	-1.0	0.1
Greece	0.5	1.2	0.6	0.1	0.7	0.7	-0.7	-0.2
Ireland	0.6	1.2	1.3	1.3	0.8	0.8	0.8	1.2
Israel	1.0	1.6	1.0	0.9	0.7	0.7	-1.2	-0.2
Italy	0.9	1.5	1.0	0.4	0.7	0.8	-1.2	-0.1
Japan	1.0	1.5	1.5	0.8	0.8	0.8	-3.1	-1.6
Netherlands	1.0	1.5	1.6	1.4	0.8	0.7	0.1	1.1
New Zealand	0.9	1.3	1.6	1.5	0.7	0.8	0.2	0.6
Norway	1.0	1.5	1.4	1.2	0.8	0.8	-0.4	-0.2
Portugal	0.4	1.3	0.9	0.7	0.7	0.7	-0.1	0.6
Spain	0.6	1.3	0.9	0.6	0.8	0.8	-0.5	0.6
Sweden	1.3	1.7	1.4	1.3	0.7	0.8	-0.7	0.6
Switzerland	1.1	1.5	1.4	1.4	0.8	0.9	-0.4	0.4
United Kingdom	0.9	1.5	1.8	1.5	0.7	0.8	-0.2	0.3
United States	1.1	1.5	1.7	1.5	0.8	0.8	-0.8	0.0
Asian Tigers								
Korea	0.6	1.3	0.9	0.5	0.6	0.7	-1.2	-0.1
Singapore	0.6	1.3	1.5	1.5	-0.6	-0.6	1.3	1.7
Taiwan	0.7	1.4	1.6	0.8	-0.2	0.7	-0.7	0.1
New EU Members								
Czech Republic	0.4	1.1	0.7	0.2	0.7	0.7	0.0	1.2
Estonia	0.2	1.1	0.6	0.7	0.1	0.7	-0.6	1.6
Hungary	0.4	1.2	1.0	0.4	0.7	0.7	-0.5	1.1
Latvia	0.0	1.0	0.1	0.0	0.3	0.7	-1.1	0.7
Lithuania	0.0	1.0	0.1	-0.2	0.2	0.7	-1.0	0.8
Poland	0.2	1.0	0.4	-0.1	0.5	0.7	-1.3	0.6
Slovakia	0.3	0.9	0.9	-0.1	0.0	0.7	-0.8	1.2
Slovenia	0.6	1.4	0.0	0.5	0.7	0.8	-0.6	0.2

West Asia								
Bahrain	0.3	0.8	1.7	1.2	-3.0	-2.4	0.1	0.5
Iran	-0.4	0.7	-1.3	-2.0	-1.7	-0.8	-1.0	-0.7
Jordan	-0.3	0.6	0.8	0.4	-0.6	-0.9	0.0	1.1
Kuwait	0.0	0.9	1.4	0.9	-1.3	-1.0	-2.1	-1.3
Oman	-0.6	0.4	1.4	0.7	-2.6	-2.4	-0.2	0.4
Saudi Arabia	0.0	0.9	1.4	0.4	-3.7	-3.6	0.0	0.1
Syria	-0.7	0.1	-0.7	-1.4	-2.5	-1.8	-0.9	0.1
Turkey	-0.3	0.6	0.3	-0.5	0.4	0.4	-0.8	0.5
United Arab Emirates	0.2	1.0	1.6	1.1	-2.8	-2.9	-0.2	0.2
Latin America								
Argentina	0.2	1.0	0.4	-1.1	0.7	0.7	-1.2	0.4
Bolivia	-0.6	0.4	-0.8	-1.5	0.6	0.6	-0.4	1.2
Brazil	-0.1	0.7	0.3	-0.3	0.6	0.7	-1.0	0.3
Chile	0.0	0.6	1.2	0.9	0.7	0.8	0.2	1.3
Colombia	-0.3	0.3	-0.7	-1.1	0.6	0.3	-0.6	0.7
Costa Rica	-0.3	0.4	0.3	0.1	0.8	0.7	0.0	0.8
Dominican Republic	-0.7	0.0	-0.6	-1.3	0.4	0.6	-0.9	0.3
Ecuador	-0.6	0.2	-0.6	-1.5	0.4	0.5	-0.5	1.0
El Salvador	-0.9	0.0	-0.1	-0.3	0.5	0.5	-1.0	0.4
Guatemala	-1.0	0.0	-0.5	-1.6	-0.1	0.3	-0.5	0.3
Guyana	-1.0	0.0	-0.6	-0.5	0.4	0.5	0.6	2.2
Honduras	-1.0	-0.3	-0.4	-1.3	0.5	0.5	-0.2	1.1
Jamaica	-0.5	0.3	0.1	-0.5	0.6	0.6	0.0	1.1
Mexico	-0.2	0.5	0.1	-0.5	0.2	0.7	0.0	1.1
Nicaragua	-0.8	-0.1	-0.9	-1.4	0.2	0.5	-0.2	1.5
Panama	-0.3	0.6	0.1	-0.7	0.5	0.8	-0.1	0.7
Paraguay	-1.0	0.1	-0.3	-2.1	0.4	0.5	-0.7	0.8
Peru	-0.4	0.4	-1.0	-1.3	0.0	0.7	-1.1	0.5
Trinidad and Tobago	-0.3	0.4	0.9	0.2	0.9	0.6	-0.4	0.9
Uruguay	-0.1	0.6	0.2	-0.1	0.8	0.9	-1.3	-0.1
Venezuela	0.0	0.8	-0.3	-2.5	0.5	0.5	-0.4	0.5
East Europe & CIS								
Albania	-0.8	0.0	-0.7	-1.5	0.3	0.5	-1.6	-0.6
Armenia	-0.4	0.4	-0.3	-0.8	0.1	0.1	-1.3	0.3
Belarus	0.0	1.0	-0.2	-1.5	-0.6	-2.4	-3.2	0.5
Bulgaria	0.2	0.9	0.1	-0.7	0.5	0.7	-1.3	0.9
Croatia	0.3	1.1	-0.8	-0.7	-0.3	0.5	-1.2	0.8
Georgia	-0.3	0.5	-1.3	-1.4	-0.6	0.3	-3.1	-0.1
Moldova	-0.4	0.4	-0.7	-0.4	-0.5	0.3	-1.9	0.9
Romania	-0.1	0.8	-0.8	-1.1	0.2	0.6	-2.1	0.8
Russia	0.1	1.1	-0.4	-1.2	-0.1	-0.2	-1.9	0.5
Ukraine	0.0	0.8	-1.3	-1.2	0.3	0.2	-2.2	0.5

North Africa								
Algeria	-0.7	0.0	-0.5	-1.1	-2.5	-0.4	-1.2	-0.1
Egypt	-0.2	0.5	-0.9	-0.5	-0.8	-0.9	-0.1	0.2
Morocco	-0.9	-0.3	0.9	0.1	-1.0	-0.9	0.2	1.7
Tunisia	-0.6	0.5	0.8	0.4	-1.4	-1.4	0.8	1.2
South-East Asia								
China	-0.5	0.7	-0.2	-0.4	-2.7	-2.4	-0.1	1.0
Indonesia	-0.8	0.0	-0.4	-1.1	-1.9	0.3	-0.3	0.0
Malaysia	-0.1	0.8	0.9	0.3	0.1	0.0	1.7	2.0
Philippines	-0.5	0.2	-0.5	-1.1	0.4	0.5	-0.3	1.1
Thailand	-0.4	0.5	0.8	0.2	0.0	0.6	0.6	1.5
Vietnam	-1.3	0.2	-2.2	-1.9	-2.5	-1.9	-0.3	1.5
Sub-Sahara Africa								
Benin	-2.1	-1.2	0.2	-0.8	0.6	0.6	-0.1	-0.4
Botswana	-1.0	-0.1	0.7	0.7	0.2	0.5	0.7	0.8
Burkina Faso	-2.2	-1.4	-0.9	-0.5	-1.4	-0.4	-1.4	-1.2
Cameroon	-1.5	-0.6	-0.9	-1.5	-0.9	-1.1	-1.4	-0.5
Congo	-1.5	-1.4	-1.5	-1.6	-0.1	-0.8	-0.2	1.4
Cote d'Ivoire	-1.1	-0.5	0.1	-1.2	-0.9	-0.5	-0.3	0.6
Ethiopia	-1.9	-1.3	-0.4	-0.7	-1.8	-0.2	-1.6	0.8
Ghana	-1.4	-0.8	0.2	-0.2	-0.8	0.5	-0.2	1.1
Guinea	-2.0	-1.2	0.1	-1.3	-2.1	-0.3	-1.3	-0.5
Kenya	-1.1	-0.4	-0.1	-0.8	-0.7	0.5	-0.1	0.3
Madagascar	-1.8	-1.2	-0.8	-0.8	0.3	0.5	-1.5	-0.2
Malawi	-2.6	-1.4	0.0	-0.2	-1.4	0.3	0.2	0.7
Mali	-2.3	-1.7	-0.5	-0.6	0.1	0.6	-0.3	0.8
Mozambique	-2.3	-1.8	-0.7	-1.2	-1.3	0.4	0.0	2.1
Namibia	-1.0	-0.2	0.8	0.7	0.5	0.3	1.2	1.5
Niger	-2.3	-1.9	-0.8	-1.3	-0.4	0.4	-0.3	0.2
Nigeria	-1.4	-0.6	0.0	-1.3	-2.0	0.3	0.6	0.9
Senegal	-1.7	-1.0	0.1	-0.5	0.1	0.5	-0.5	0.9
South Africa	0.2	0.5	0.7	0.4	0.3	0.7	-0.3	1.0
Tanzania	-2.1	-1.7	0.3	-0.4	-1.3	0.1	0.4	1.6
Togo	-1.5	-0.7	-0.7	-1.8	-1.4	-0.9	-0.9	0.4
Uganda	-1.7	-0.9	0.4	-0.4	-1.7	-0.7	-1.7	0.1
Zambia	-1.6	-1.3	-0.4	-0.5	0.3	0.2	0.8	1.8
Zimbabwe	-0.9	-0.1	0.2	-2.5	-0.8	-1.3	-0.9	1.4
Central Asia								
Bangladesh	-1.5	-0.5	-1.5	-2.0	0.6	0.3	-2.3	-0.7
India	-0.9	-0.1	0.0	-0.1	0.4	0.6	-2.3	-0.5
Mongolia	-0.8	0.0	0.4	-0.4	0.2	0.2	-0.1	1.8
Nepal	-1.3	-0.6	-0.7	-1.1	0.3	-0.7	-2.1	-0.9
Pakistan	-1.3	-0.6	-0.4	-0.7	0.4	-1.6	-0.8	0.2
Sri Lanka	-0.9	0.1	-0.3	-0.3	0.2	0.4	-0.4	0.2
Oceania								
Papua New Guinea	-1.6	-1.1	0.4	-0.1	0.6	0.7	0.7	2.3
Fiji	-0.5	0.4	-0.1	-0.4	0.1	0.3	-0.2	0.2

Note: For definition of the variables see Table 1.